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THIS DOCUMENT DESCRIBES A PLAN OF ACTION TO ALLEVIATE OFF-POST CONTAMINATION AT RMA. THIS PLAN INTEGRATES THE WORK OF ALL INVOLVED AGENCIES INTO AN ORGANIZED EFFORT TO PRECLUDE FURTHER WATER CONTAMINATION, IDENTIFY AND QUANTIFY ANY CONTAMINANTS PRESENTLY EXISTING IN THE WATER BOTH ON AND OFF ARSENAL PROPERTY, PREDICT MIGRATION OF CONTAMINANTS, AND ESTABLISH WATER STANDARDS FOR CONTAMINANTS IDENTIFIED.

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ROCKY MOUNTAIN ARSENAL

OFF-POST CONTAMINATION CONTROL PLAN

30 MAY 1975

ROCKY MOUNTAIN ARSENAL

OFF-POST CONTAMINATION CONTROL PLAN

30 May 1975

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RMA OFF-POST CONTAMINATION CONTROL PLAN

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I. INTRODUCTION

A. Document Purpose

This document describes a plan of action to alleviate off-post contamination at Rocky Mountain Arsenal. This plan integrates the work of all involved agencies into an organized effort to preclude further water contamination, identify and quantify any contaminants presently existing in the waters both on and off Arsenal property, predict migration of contaminants, and establish water standards for contaminants identified.

B. Background

1. History and current mission of Rocky Mountain Arsenal (RMA).

a. Rocky Mountain Arsenal was established in 1942 and originally encompassed 19,776 acres northeast of the city of Denver and 7 miles south of the city of Brighton. It was built to produce toxic chemical and incendiary munitions (See Figure 1-1).

b. During World War II, Rocky Mountain Arsenal manufactured and assembled 87,000 tons of chemical intermediate and toxic end item products, and 155,000 tons of incendiary munitions. During the production period the Arsenal employed an average of 3,000 civilian and military personnel.

c. In 1945, Rocky Mountain Arsenal was placed in a standby status. During the period from 1945 to the beginning of the Korean conflict in 1950, the primary activities at the Arsenal were maintenance and renovation of Chemical Corps supplies and equipment, industrial mobilization planning, and demilitarization of obsolete hazardous and toxic munitions.

d. In 1946, certain portions of the Arsenal were leased to private industry for chemical manufacturing; at the present time a number of the original manufacturing facilities are leased to Shell Chemical Company, which manufactures various insecticides. All leased facilities are covered by a recapture clause in the event of a national emergency. The current Shell lease will expire in 1987.

e. The second large construction phase of the Arsenal was the construction of the SARIN (GB) toxic chemical agent facility. This manufacturing and filling facility was completed in 1953 and actively manufactured GB until 1957.

f. After the Korean emergency, RMA provided testing services and technical assistance to industry for the production of chemical, incendiary and smoke munitions. From 1959 through 1962, Rocky Mountain Arsenal produced biological anti-crop agent and, from 1965 through 1969, emptied Cyanogen Chloride (CK) and Phosgene (CG) bombs for shipment to a commercial manufacturer for filling with high explosives.

g. In 1968 an Ad Hoc Committee of the US Army Materiel Command staff made a decision that all excess and obsolete chemical stocks stored at

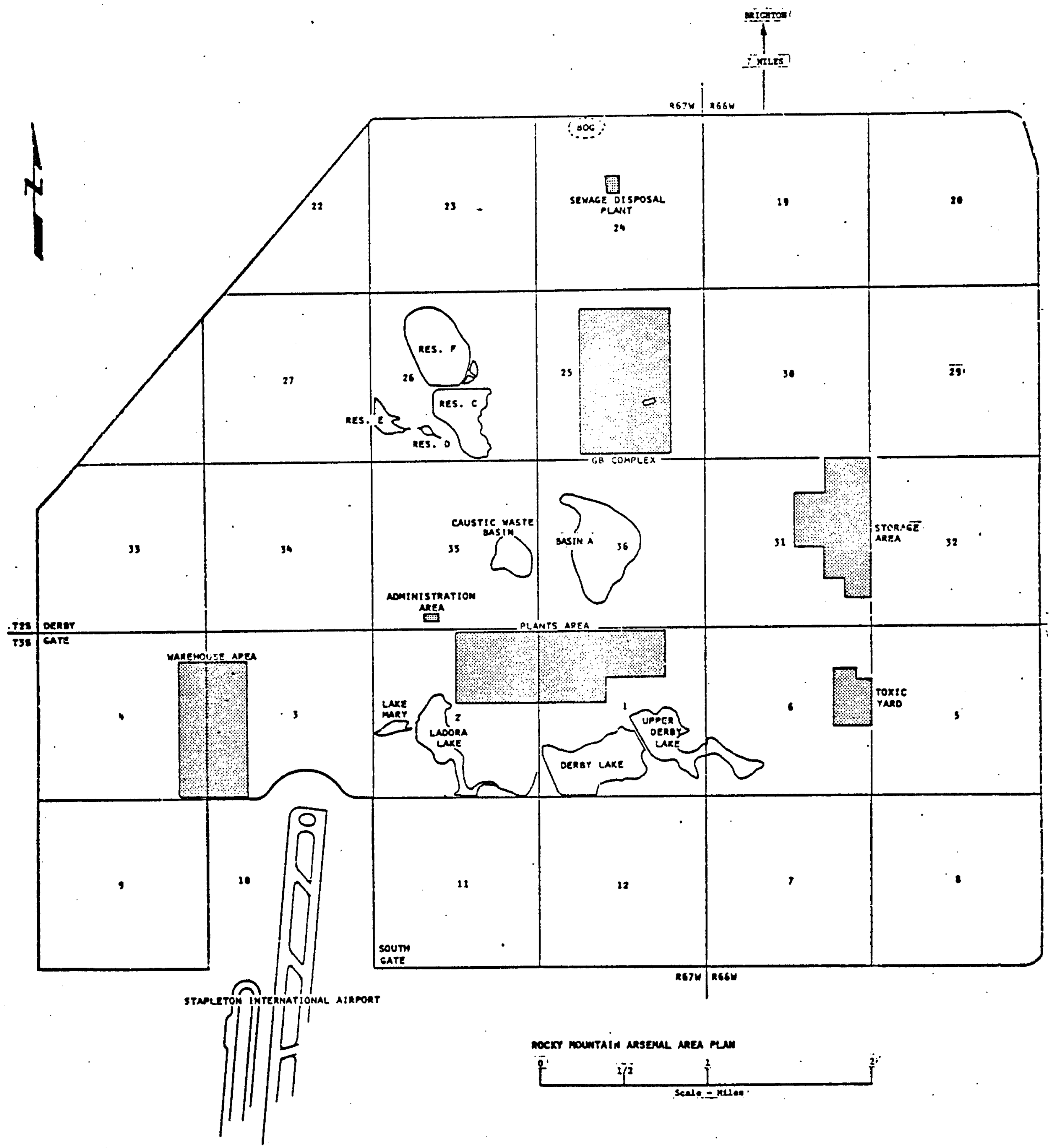


Figure 1-1. Rocky Mountain Arsenal Plan View

Rocky Mountain Arsenal be disposed of by dump at sea. This plan was called Operation Chase. Public and Congressional concern over the safety of Operation Chase resulted in its cancellation. The Department of the Army then requested the National Academy of Sciences (NAS) to convene a special committee to review disposal methods for chemical agents and to make recommendations as to how the Army could accomplish this task with maximum safety.

h. In October 1973 Project Eagle was initiated which involved the demilitarization of obsolete M34 cluster bombs containing GB nerve gas (SARIN) stored at the Arsenal. Expanded Project Eagle added the demilitarization and disposal of the Army Honest John warhead, and the Navy Weteye bomb containing GB. (Weteye bombs stored at RMA contain no explosive). In addition, GB held in bulk underground tanks was neutralized and ton containers stored on the surface will be emptied and their contents detoxified. All demilitarizing activities are performed in the GB plant complex.

i. The Plants Area contains the buildings primarily used in WWII production or processing of Mustard, Chlorine, Phosgene and Lewisite chemical agents. The Shell Chemical Company currently leases 12 of these buildings for use in the production of pesticides. This area was the site for the Mustard Demil Program completed in March 1974 and will be the site of the Phosgene Disposal Program to be completed in 1976. A Hydrazine blending plant is operated on an as-required basis in the area to provide liquid rocket fuel to the USAF and NASA.

j. Other areas of the Arsenal contain support facilities such as Headquarters, housing, procurement and surplus disposal, Security offices, Power Plant, Laundry, QA Lab, Fire Station, air monitoring points, toxic storage yard and engineering offices for the government and contractors.

2. Chronology of Off-Post Contamination

a. The first indication of off-post contamination occurred in the summer of 1951 when some minor crop damage was observed on an irrigated farm northwest of Rocky Mountain Arsenal. At this time, the crop damage was not attributed to ground water contamination by RMA. In the summer of 1954 several farmers complained that ground water used for irrigation had damaged their crops. (The precipitation in 1954 was considerably below average and increased pumping from irrigation wells was required to produce crops). Due to the increase of complaints and subsequent claims for damage, the Department of the Army took the following actions:

(1) Retained a firm of consulting engineers to investigate the problem of ground water contamination.

(2) Requested the U.S. Geological Survey to study water quality on the Arsenal and on neighboring farmlands.

(3) Contracted the University of Colorado to undertake plant bioassay, chemical, and geological studies to determine the identity and source of contaminants causing crop damage.

b. As a result of the first action, Reservoir F was constructed and, since early October 1955, all industrial wastes have been pumped to this reservoir. To preclude ground water contamination, the bottom of Reservoir F was constructed of asphalt and lined with a waterproof membrane. The two studies conducted by USGS and the University of COlorado indicated that the primary contaminants were sodium and chlorides and that these contaminants were carried off-post by underground water which travelled in a northwesterly direction (See Figure 1-2). The authors of these studies did not investigate the possibility of ground water flow to the north. In addition to the above actions and studies, the Colorado State Department of Health, in cooperation with the Department of the Army, started to monitor selected wells.

c. In 1972 Mr. Larry Land, a farmer north of the Arsenal, filed a claim against Shell Chemical Company (SCC) for the alleged death of cattle, diminution in property value, and personal injury as a result of allegedly consuming contaminated well water. On March 23, 1973, the Honorable Fred Winner, Judge for the United States District Court for the District of Colorado ruled, among other things, that he would accept plaintiff Land's motion to dismiss, with prejudice, the claim made against Shell Chemical Company. Judge Winner also concluded before ruling on the motion to dismiss as to Shell Chemical Company that accepting the averments of the complaint as true and regarding the same as judicial admissions, he found that the alleged wrongs, whether deemed wrongful or negligent, were not the primary cause of the alleged injuries even under the position taken by plaintiff Land. Since that time Mr. Land has retained a new attorney. Commencing in January 1975, various claims have been filed on the United States Government essentially alleging the same injuries as originally pled in the above referenced case.

d. In May of 1974, diisopropylmethylphosphonate (DIMP) and dicyclopentadine (DCPD), were detected in surface water draining from a marshy bog on the northern boundary of the Arsenal. DIMP is a persistent compound produced in small quantities (less than 3%) during the manufacture of GB. DCPD is a chemical used in the production of insecticides. These compounds are described in Appendix A. Detection of these two compounds resulted in the following actions:

(1) More wells were drilled and the well monitoring program was expanded to include tests for these and other compounds.

(2) In September of 1974, a dike was constructed north of the marshy bog to eliminate off-post surface drainage.

(3) Rocky Mountain Arsenal and Ft. Detrick established programs to determine the effect of DIMP on wheat growth.

e. In December of 1974, the Colorado Department of Health detected DIMP in a well near the City of Brighton. This data was published in "1974-75 Ground Water Study of the Rocky Mountain Arsenal and Some Surrounding Areas" and is based on comparison with synthesized DIMP rather

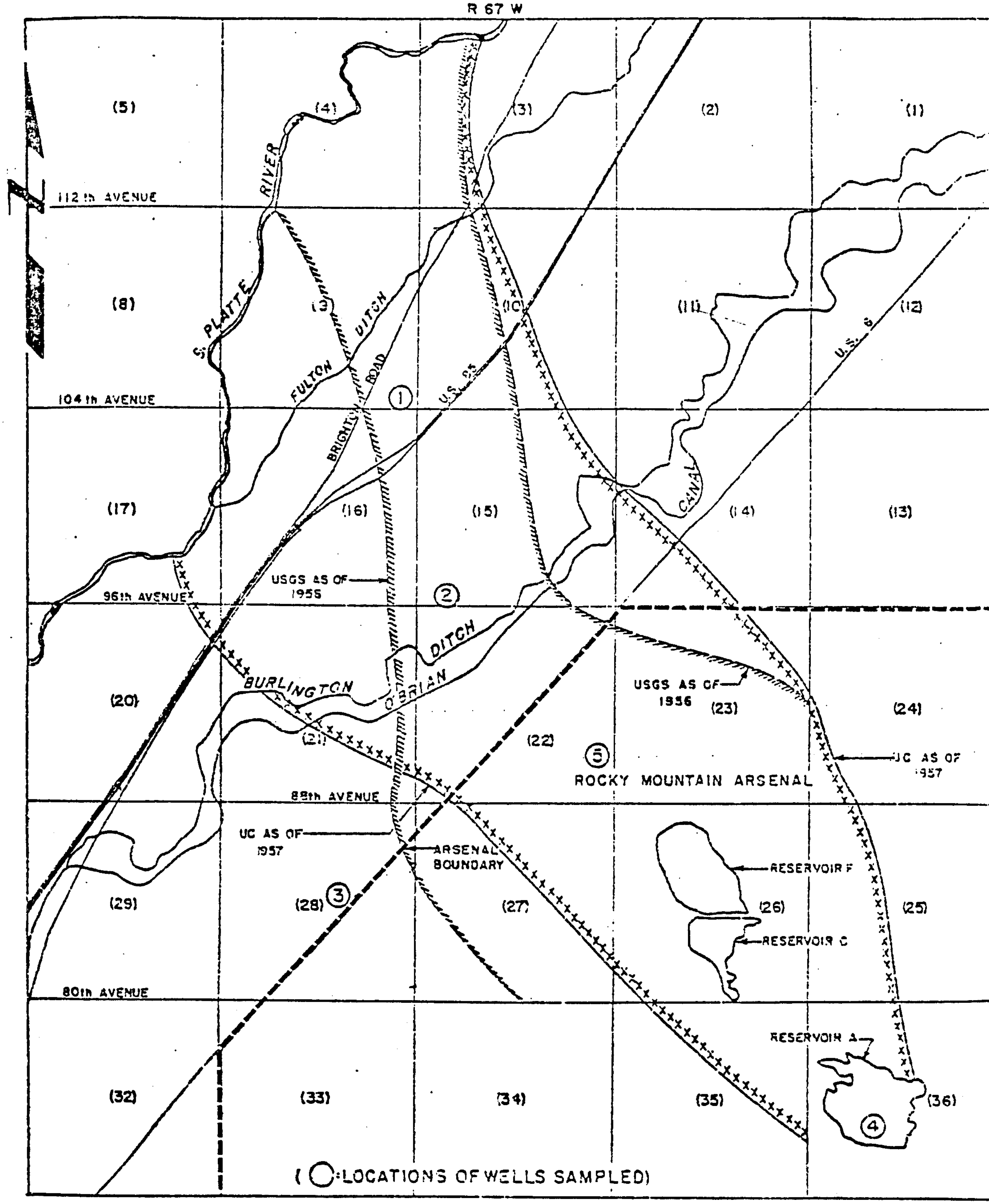


Figure 1-2. Suspected Area of Shallow Ground Water Contamination as of 1956 & 1957

than DIMP samples submitted by RMA to the Department of Health. Although the quantity of DIMP detected was extremely small (0.57 parts per billion), it indicates that ground water may travel in a northerly direction. A two year study by USGS (See Section II) tends to confirm this additional direction of ground water flow.

f. The detection of DIMP and DCPD in surface water off the Arsenal and DIMP in wells near Brighton led to the State of Colorado Department of Health issuing three Cease and Desist Orders on 7 April 1975 against Shell Chemical Company and Rocky Mountain Arsenal. In short, these orders stated that:

(1) SCC and RMA immediately stop the off-post discharge (both surface and subsurface) of DIMP and DCPD.

(2) Take action to preclude future off-post discharge (both surface and subsurface) of DIMP and DCPD.

(3) Provide written notice of compliance with item (1).

(4) Submit a proposed plan to meet the requirements of item (2).

(5) Develop and institute a surveillance plan to verify compliance with items (1) and (2).

g. Since this order was issued, off-post contamination has received increased attention and is further addressed in the remainder of this document.

II. DESCRIPTION OF RMA NATURAL WATERFLOW SYSTEM

The natural waterflow system at Rocky Mountain Arsenal is comprised of water flowing on the land surface and water flowing in the alluvial aquifer.

A. Surface Water

1. The natural flow of surface water across RMA is shown in Figure 2-1. In general, the natural flow is in a northwest or westerly direction and, although the flow lines are solid, all flow is intermittent. First Creek flows across the eastern portion of the Arsenal and encounters no known contaminated areas. The lakes, starting with Upper Derby Lake and ending with Lake Mary, get progressively lower so that the flow is practically due west.

2. All man-made storm drainage in the old plants area flows south into Upper Derby and Derby Lakes. All storm drainage west of Lake Mary and Reservoir F flows west and is usually absorbed by arid areas before it leaves the Arsenal. All remaining storm drainage is directed to the natural flow channels.

B. Alluvial Aquifer

1. The alluvial aquifer or subsurface water flow at RMA is shown in Figure 2-2. This map shows the water table contour lines as developed by USGS during 1973 and 1974. The cross hatched areas indicate where the alluvium is absent or unsaturated (no water flow). There is seasonal variance in water table levels and consequently, the levels shown in Figure 2-2 may vary by a few feet from year to year. The general direction of ground-water flow is from regions of higher water table altitudes to lower water table altitudes and approximately perpendicular to the water table contours.

2. Deviations from the general flow pattern may occur in some areas because of variances in aquifer properties. The map indicates that ground water could flow in a northerly direction as well as in the generally accepted northwesterly direction.

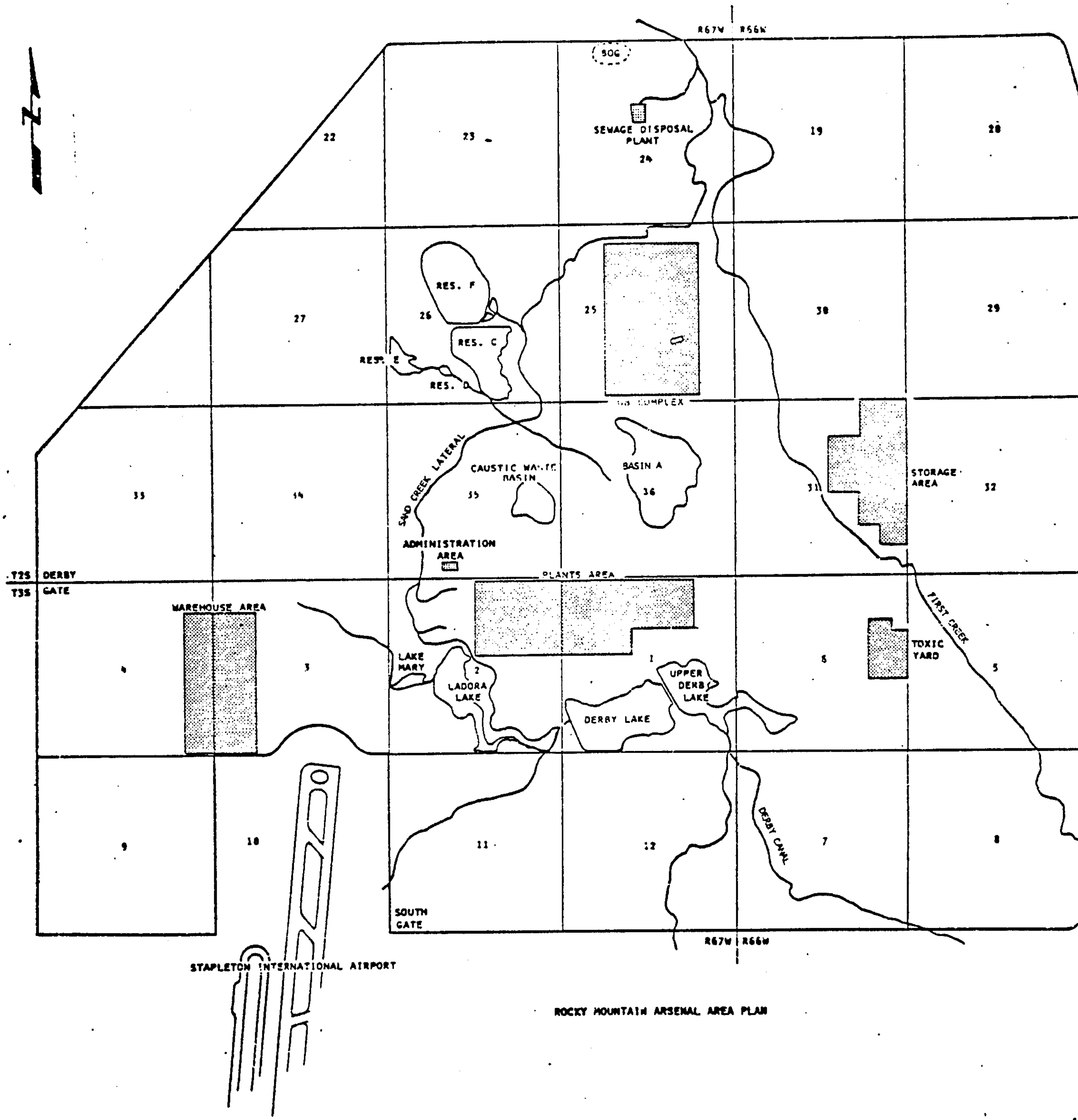


Figure 2-1. Surface Water Flow Pattern

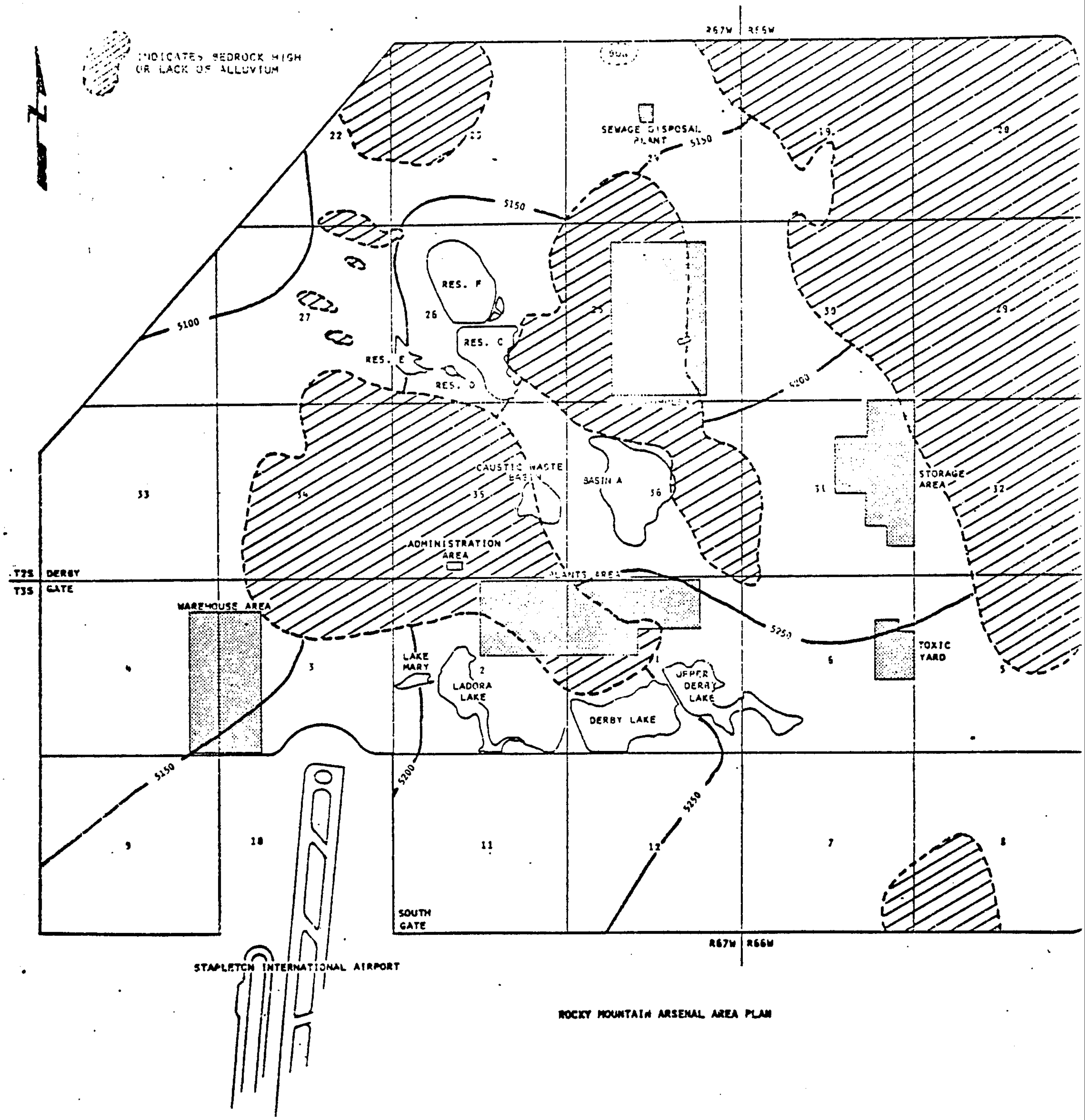


Figure 2-2. Subsurface Water Flow Pattern Based On Bedrock Highs

III. DESCRIPTION OF SOURCE AND FLOW OF CONTAMINANTS

The two most likely sources of contaminants at RMA are Basin A and the contaminated sewer lines. Another possible but less likely source is one of the two small diked areas southeast of Reservoir F. (See Figure 2-2.)

A. BASIN A

The contaminated area of Basin A, located in section 36, is approximately 300 acres. This area was used as an industrial waste basin from 1942 through October 1955, when Reservoir F was constructed. During this time period large quantities of mustard and GB byproducts were dumped in this area. In addition, this area was used as an industrial waste basin for part of the World War II production facility (Plants Area) which were leased to private contractors prior to Shell Chemical Company initiating its operation in 1950. From these production processes, waste material such as organophosphates and chlorinated hydrocarbons have been deposited in large quantities. Large claims against the Department of Army were paid from 1955 to 1960 due to aquifer contamination from waste products in this basin. Since Basin A is one of the lowest places on the Arsenal in relation to the water table elevations, it is assumed that it is the most probable source of ground water contamination.

B. CONTAMINATED SEWER LINE

The contaminated sewer line (dashed) and the utility sewer line (solid) are shown in Figure 3-1. The utility sewage line has several lift stations to permit a northerly gravity flow to the sewage disposal plant. The contaminated sewer line has one lift station denoted by the circle in section 36. This lift station pumps chemical waste from a sump in the GB Complex to Reservoir F. There is some doubt as to the integrity of the chemical waste line feeding Reservoir F and the two small diked areas southeast of Reservoir F. If there is a leak in either one of these areas, it could be a source of both surface and ground water contamination.

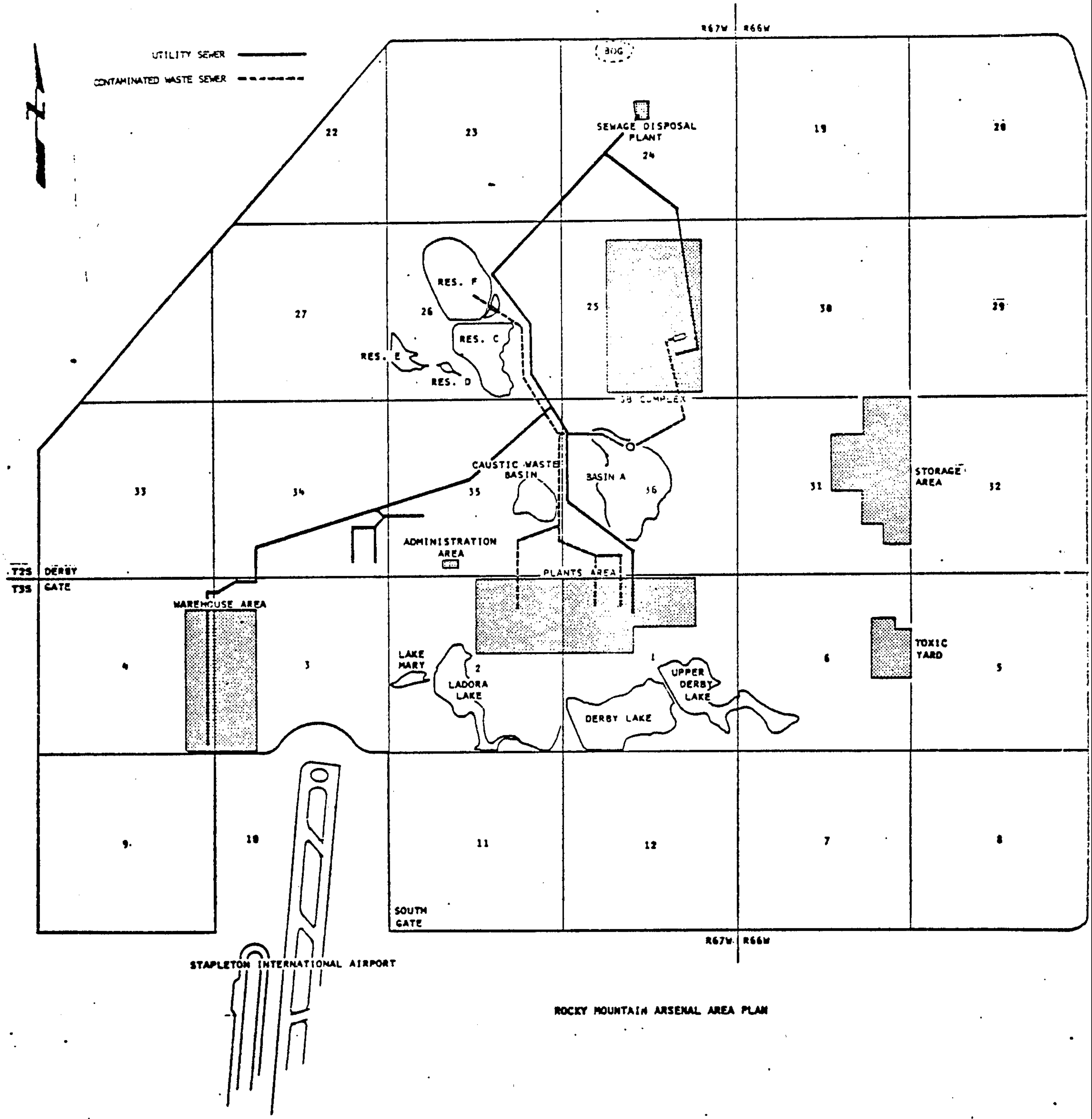


Figure 3-1. Contaminated Waste and Sewer Lines

IV. PLAN OF ACTION TO PRECLUDE FURTHER CONTAMINATION

A. Surface Water

To preclude the discharge of contaminated surface water from Arsenal property, the only known contaminated surface water discharge point was eliminated. The bog on the northern boundary of the Arsenal is being pumped to Reservoir F to lower the water level in the bog. This pumping operation will continue on a part time basis until the source of contamination is eliminated and the bog waters are rendered free of contaminants (See Figure 4-1).

B. Subsurface Waters

1. Basin A and a possible leak in the chemical waste sewer line at Reservoir F are the probable sources of contamination in the alluvial aquifer.

2. To prevent water from leaching contaminants from the soil in Basin A, the basin will be graded and contoured to allow for immediate run off of rain water. A ditch will be constructed running south to north along the west side of Basin A which will provide a drainage bypass for surface water runoff from the plants area (See Figure 4-1). Four wells will be drilled across the bedrock draw just northwest of Basin A. Water will be pumped out of the wells into the chemical sewer line which leads to Reservoir F. This will eliminate some contaminated water from the aquifer under Basin A and effectively lower the level of the aquifer under Basin A. Lowering of the aquifer will further reduce the leaching of surface contamination. A bentonite dam may be constructed downstream from the line of wells by digging a trench to shale bedrock and backfilling the trench with a bentonite/mud slurry. This proposal is being evaluated but no decision to proceed has been made at this time. This dam would prevent contaminated water from bypassing the line of wells.

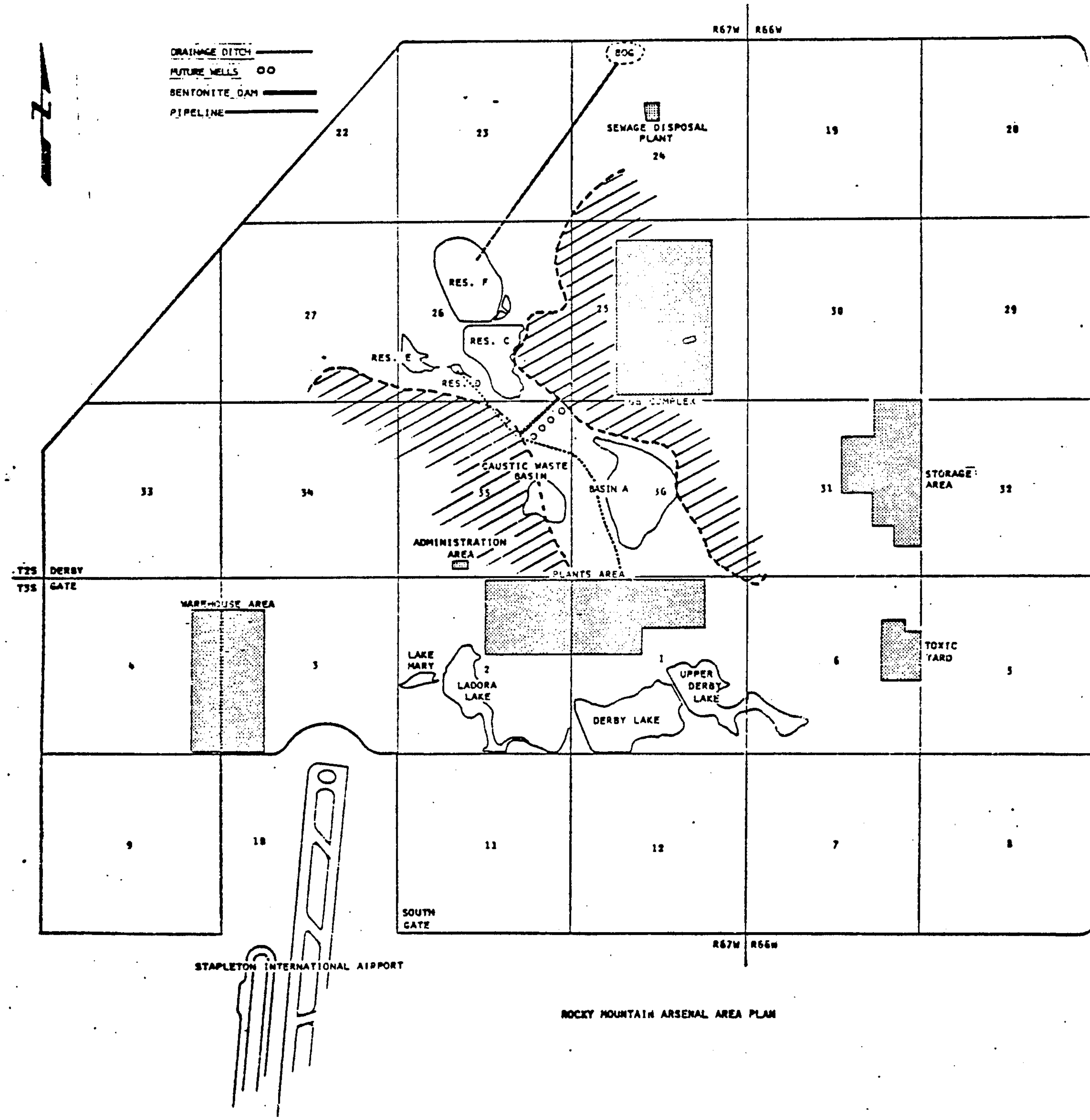


Figure 4-1. Construction For Contamination Control

V. WATER MONITORING AND SURVEY PROGRAM

The water monitoring and survey plan consists of two separate plans being conducted simultaneously. The Brighton Sampling Plan is being conducted to comply with the Cease and Desist Orders. The Claims Sampling Plan is being conducted to gether contamination data in regards to existing claims against RMA.

A. Brighton Sampling Plan

In conjunction with the State of Colorado Department of Health and Shell Chemical Company, RMA has developed an extensive sampling plan to define aquifer contamination both on and off-post. All on-post and some off-post wells to be monitored are shown in Figure 5-1. Roman numeral designators were assigned by the State. Wells carrying an NS designator are new wells scheduled to be drilled. Cost factors and negotiation difficulties with land owners preclude listing well completion dates at this time.

Collection of samples from Arsenal wells is the responsibility of RMA and collection of samples from off-post wells is the responsibility of the Tri-County Health Department. On-post sample collection was started on 5 May 1975, and is based on a four-week cycle as listed in Table 5-1. As of 15 May, no off-post collection schedule had been established; therefore, no off-post wells have been listed. Sample collection will continue, as scheduled, for a minimum of six months. At the end of six months, the plan will be reviewed, revised (if required), and probably extended for an additional six months. On and off-post samples will be analyzed by all three participants for the contaminants listed in Table 5-2. At the completion of each analysis, results from all three participants will be compared. In addition, the State Department of Health will analyze off-post samples for chlorate, nitrate, sodium, sulfate, and total hardness. Qualitative and quantitative analysis for both DIMP and DCPD will be by the gas-liquid chromatographic method with a flame ionization detector. Analysis for the remaining contaminants will be accomplished by using standard laboratory methods.

WEEK	DAY	WELL NUMBERS
1	Mon.	38, 37, 23, 22
	Wed.	103, 67, 17, 126
2	Mon.	142, 41, 141, 145, 11
	Wed.	62, 73, 127, 117
3	Mon.	104, 124, 3A, 118
	Wed.	105, 72, 132, 133, 134
4	Mon.	75, 115, 122, 123
	Wed.	121, 60, 79 . 45

Table 5-1. Schedule for Brighton Sampling Plan

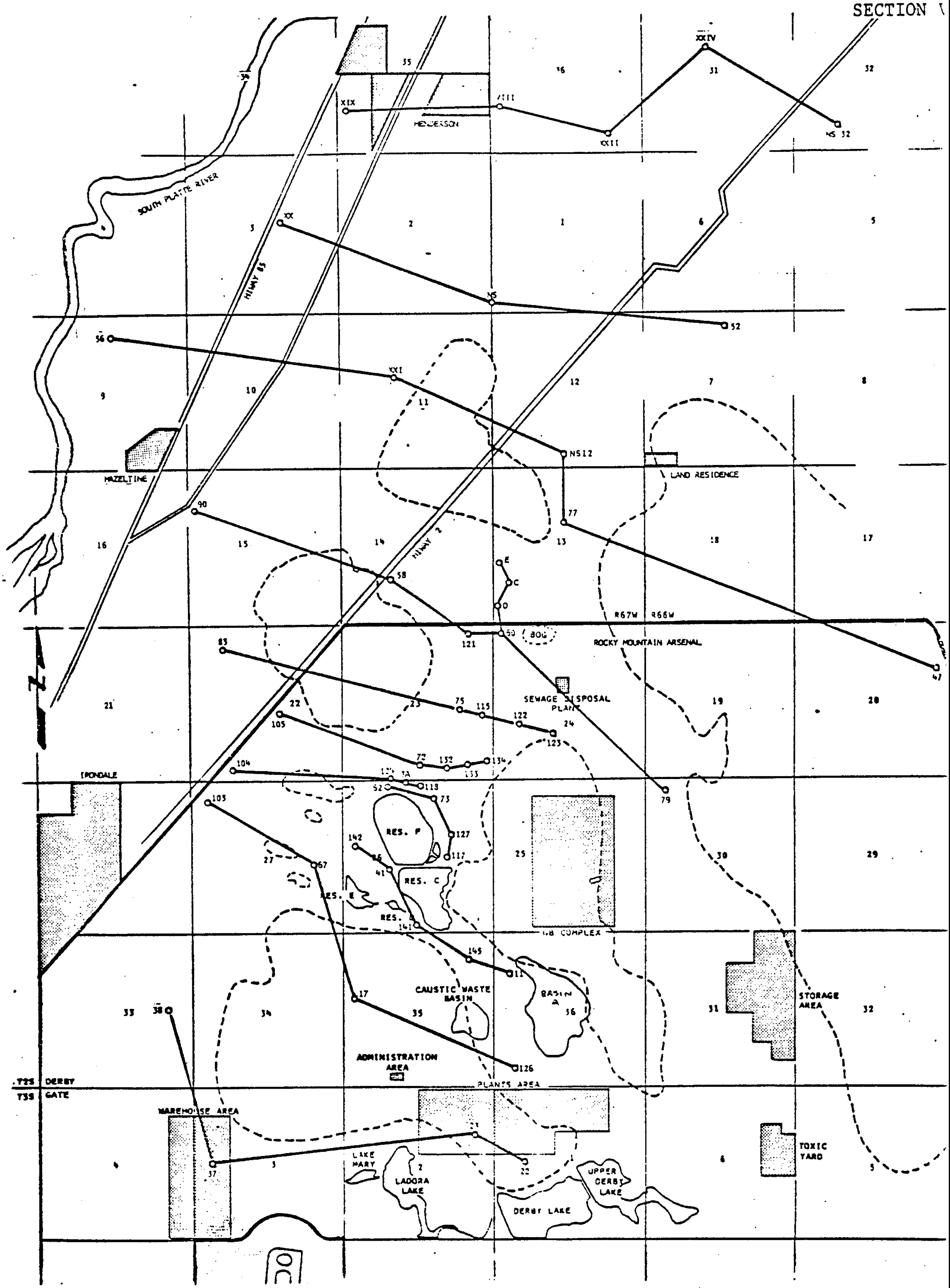


Figure 5-1. Wells for Brighton Sampling Plan.

TEST FOR:	SHELL CHEM. CO.	RMA	DEPT. OF HEALTH
DIMP	X	X	X
DCPD	X	X	X
Copper	X	X	X
Fluoride	No	X	X
Chloride	X	X	X
pH	X	X	X
Pesticides	X	X	X

Table 5-2. Analysis For Brighton Sampling Plan

B. Claims Sampling Plan

Due to claims filed against RMA, a Claims Sampling Plan is being conducted in cooperation with the State Department of Health. This plan was initiated on 5 May and is scheduled to last six weeks. At the end of six weeks, the plan will be reviewed. Weekly samples are collected by RMA from the on-post wells shown in Figure 5-2. Again, off-post sample collection schedule has been established. Due to this and the relatively short time frame, RMA has randomly collected off-post samples at the convenience of the land owners. Both RMA and the State Department of Health analyze all samples for the following:

DIMP	Fluoride
DCPD	Nitrate
Chlorate	pH
Chloride	Sulfate
Copper	Total hardness

Analytical procedures are the same as those used for the Brighton Sampling Plan.

C. Supplemental Efforts

Prior to initiation of the two sampling plans, RMA was (and is currently) collecting and analyzing samples from other wells. This effort is directed to detection of contamination, if it occurs, eminating from waste basins and reservoirs. Also, infra-red aerial photographs have been taken of RMA and surrounding areas. These photographs are presently being studied to evaluate the use of this technique for determining aquifer flow, or other subsurface features which may affect the migration of possible contaminants.

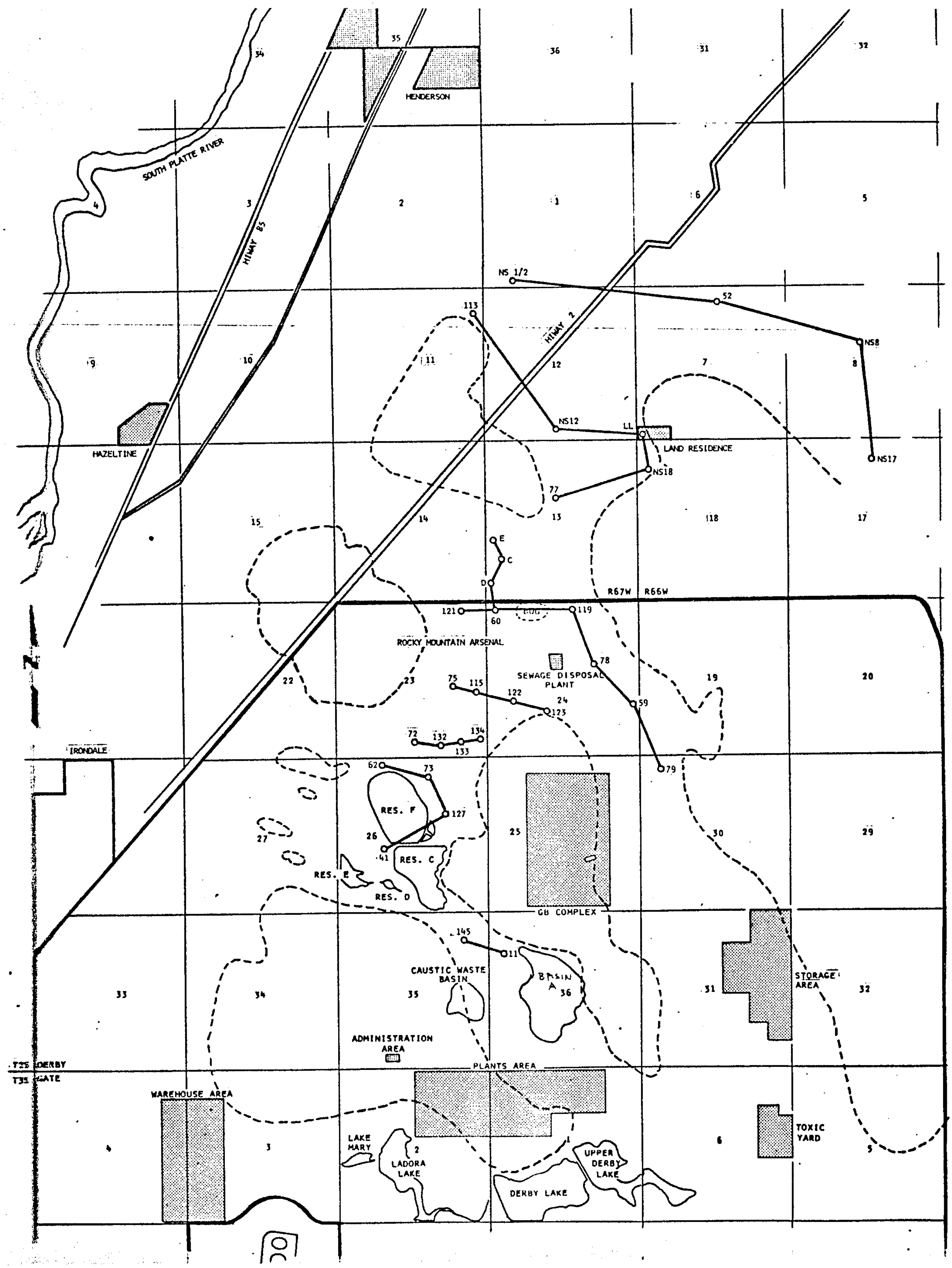


Figure 5-2. Wells for Claims Sampling Plan

VI. PLAN FOR DEVELOPMENT OF COMPUTER MODEL TO PREDICT DIMP MIGRATION

A. The movement of chloride at the Rocky Mountain Arsenal has been studied by the US Geological Survey as part of a program to devlop models of transport of non-reactive soluble chemical constituents in ground water. Chloride was chosen for modeling because it was known to exist in large concentrations in the liquid wastes and because its concentration had been measured in observation wells several times since 1955. Basic hydrogeologic information necessary for modeling the aquifer was also available.

B. The model studies have been completed. The ground water model was calibrated to accurately predict the transport of non-reactive soluble contaminants by comparison of observed changes in chloride distribution with modeled changes in chloride distribution. Because the natural background concentration of chlorides in the aquifer may exceed 150 mg/l in the vicinity of the Arsenal, the boundaries of the model study did not extend beyond the area in which chloride concentrations were reduced by more than a factor of about 50 from the source concentration.

C. Recently, DIMP has been detected in ground water in and north of the Arsenal. Since DIMP does not naturally occur in ground water, the probable source is Arsenal waste. The presence of DIMP in any detectable concentrations is evidence that contaminants have travelled from Arsenal lands to the points of detection,

D. The transport of DIMP for such distances characterizes it as a non-reactive soluble constituent. The transport of DIMP may then be amenable to analysis and prediction using the ground water chemical transport model developed by the U.S. Geological Survey.

E. It is planned to modify the model (developed for chloride distribution) to predict the ground water transport of DIMP from the Arsenal and to predict changes in its concentration. Specifically, the U.S. Geological Survey ~~will~~ conduct a study in three phases as follows:

1. Phase I

a. Incorporate chemical transport features in current chloride model. DIMP will be modeled using historical information available from Arsenal records on disposal and chemical character of wastes. Analysis will be made to compute present distribution of DIMP in the aquifer. Duplication of the present-day observed distribution of DIMP will constitute calibration of the model for the following step.

b. Predict the future movement and dispersion of DIMP in the aquifer. This analysis will include projections of the maximum extent of DIMP within detectable limits. Projections will be made to trace the rate of travel of the plume of DIMP, defining maximum concentrations and arrival times.

2. Phase II

a. Extend existing ground water model boundaries north beyond the extent of mapped chloride contamination, bounding the model on the west by the South Platte River and on the east by impermeable deposits. Data on transmissivity, depth to bedrock, and water table configuration in the area of extension have been previously compiled as a part of U.S. Geological Survey studies in the South Platte River valley.

b. Hydraulic calibration of the model will be made to assure that hydrogeologic parameters modeled are correct and consistent with one another. This will be an intermediate check prior to verification of the total ground water chemical transport model.

c. Chemical transport features will be incorporated in the model. DIMP will be modeled using historical information available from Arsenal records on disposal and chemical character of wastes. Analyses will be made to compute present distribution of DIMP in the aquifer. Duplication of presently observed distribution of DIMP will constitute calibration of the model for the following step.

d. Predictions of DIMP migration in the expanded model will be developed. Special attention will be given to Brighton and other potentially sensitive points in the aquifer.

3. Phase III

Formulate and model analysis of alternate plans for measures to alleviate ground water contamination.

VII. PLAN TO DEVELOP WATER STANDARDS FOR DIMP AND DCPD

A. Edgewood Arsenal Preliminary DIMP Toxicity Studies

1. Background

DIMP has been found in well water on and around RMA. Concentration levels of 10-12 ppm DIMP has been found on the Arsenal and levels of 0.6 to 7.0 ppb have been found off-post. Based on acute oral toxicity information in animals, human consumption would have to exceed thousands of gallons of water containing these concentration levels of DIMP to receive a lethal or near-lethal dose. No information is available about the affects of repeated exposures to low concentration levels of DIMP. To provide some insight into this aspect of toxicity, the study outlined below has been initiated.

2. Procedure

a. A total of 200 albino Edgewood Arsenal colony rats (100 male and 100 female) are in use in this study. Animals are housed five per cage for the first 30 days and four per cage thereafter, except during the period of reproduction evaluation, for a total exposure period of 26 weeks.

b. DIMP is being given to the animals in various concentration levels in drinking water. No other source of water will be available to these animals throughout the six month exposure period so that all animals will drink as much water as required for survival. Water consumption for each cage (four to five animals) is monitored daily. Body weight for each animal is monitored weekly.

c. Animals are divided into five groups of 40 animals each (20 males and 20 females) for exposure to the following concentration levels of DIMP water.

DIMP Concentration	Number of Animals	
	Male	Female
1,000 ppm	20	20
10 ppm	20	20
6 ppb	20	20
0.6 ppb	20	20
Control	20	20
TOTAL	100	100

Table 7-1. DIMP Concentrations In Drinking Water

d. After approximately 30 days of continuous exposure, four males and four females from each tested group will be sacrificed for gross and microscopic examination. The remaining animals will continue on exposure for a total of six months, at which time they will be sacrified for gross and microscopic examination.

e. During the period between 10 weeks and 26 weeks of exposure, all animals in the higher two exposure concentration groups will be used to evaluate the reproduction effects of DIMP. By delaying reproduction until after 10 weeks of exposure, it can be assured that all male animals have been exposed. During the period of one complete spermatogenetic cycle, should DIMP have effect at any particular part of the cycle, it can be assured that exposure occurred during that period. Males and females will be placed together on a one-to-one basis per cage. They will be allowed to breed, whelp and wean their young. During this entire period the water supplied to the animals will contain the same concentration of DIMP as before breeding. This procedure will cover all aspects of reproduction including dominant lethal mutagenesis and teratogenesis.

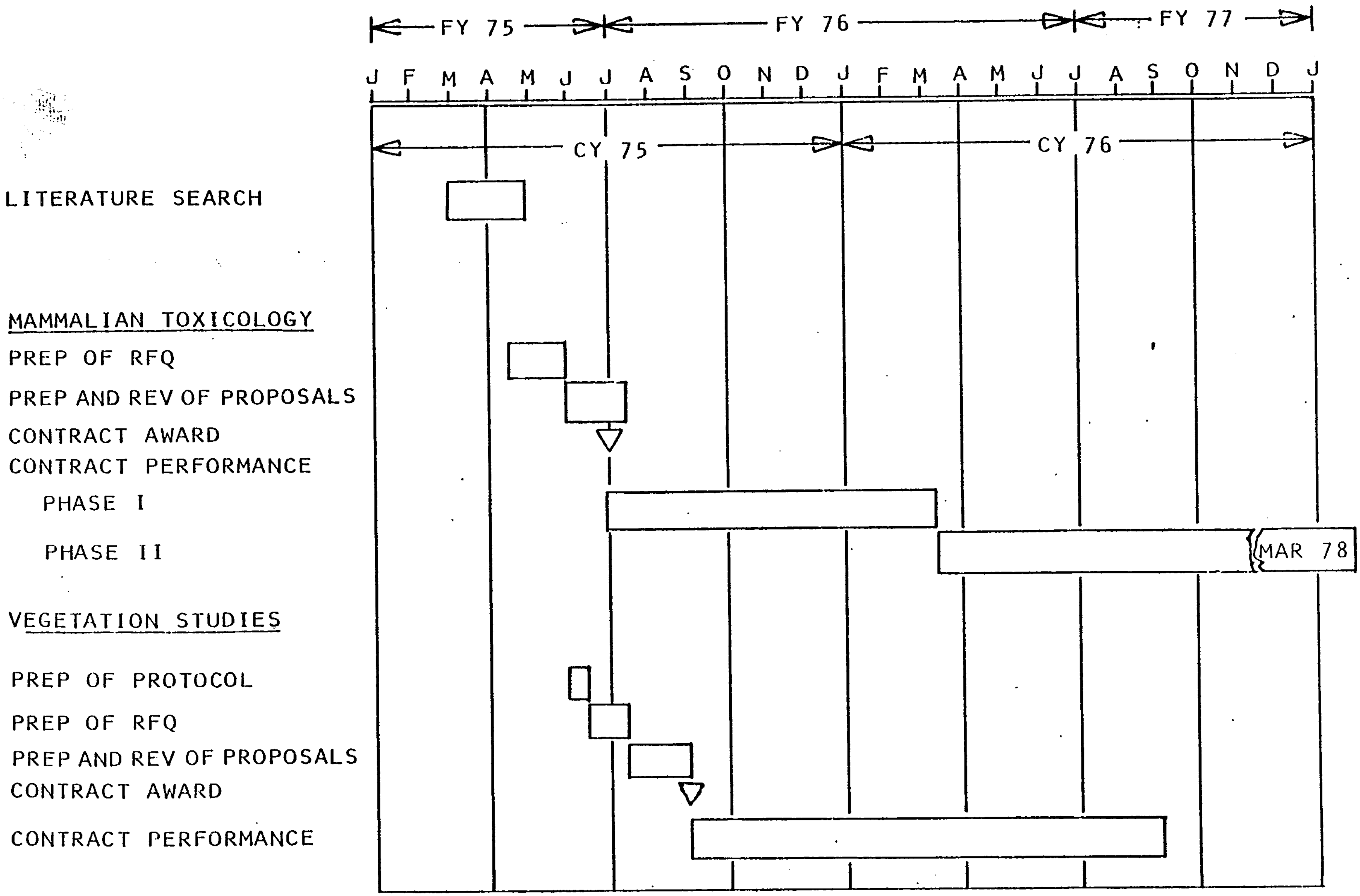
B. Army Surgeon General's Plan

The Office of the Surgeon General has been tasked to develop standards for several compounds (including DIMP and DCPD) located at RMA. Since the off-post detection of DIMP and DCPD, the standards development for these two compounds has been accelerated. The revised program schedule is presented in Figure 7-1. As shown, the literature research has been completed; however, additional data may be located when conducting literature research for other compounds. The remaining tasks are mammalian toxicology and vegetation studies. These studies will receive periodic review and coordination by the National Academy of Sciences (NAS) Advisory Committee on Military Environmental Research, the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Health, Education and Welfare (HEW). Close technical review will be provided by members of the U.S. Army Medical Research and Development Command (USAMRDC) Source Selection Boards established to evaluate research proposals and recommend contractors for contract award.

1. Mammalian Toxicity

Normally a toxicity study is separated into three phases to evaluate a compound following single, multiple, and lifetime exposure. These phases, referred to as acute, sub-acute and chronic testing, characteristically involve a progression to lower doses and longer test periods. Due to the urgency of the situation, the acute and sub-acute studies will be consolidated in a Phase I contract and the chronic studies will be conducted under a Phase II contract. This will allow a faster generation of toxicity data by eliminating the administrative decision step normally necessary when proceeding from acute to sub-acute studies. The specific tasks to be conducted during Phase I are oral LD50 (lethal dosage for 50 percent of test animals) in mice and rats, dermal LD50 in mice and rats, dermal irritation in rabbits, occular irritation in rabbits, comparative absorption, distribution, biotransformation, excretion and pharmokinetics, and 90 day feeding studies in mice, rats, and dogs. Phase II tasks are assessments of carcinogenicity, teratogenicity, and mutagenicity, reproduction studies, and detailed metabolism studies with emphasis on the isolation and identification of metabolites.

HEALTH EFFECTS EVALUATION OF DIMP & DCPD IN GROUND WATER



2. Vegetation Studies

Studies will be conducted under contract following competative procurement with contract award prior to 15 September 1975. Two parallel efforts will be conducted to determine the direct effects on plant growth and production and to determine the uptake of the test compounds by vegetative species. The scheduled activities are outlined in Figure 7-1. The vegetation studies will be conducted on several plant species representative of those cultivated in the vicinity of RMA. Comprehensive phytotoxicity studies will determine the dose response relationship of DIMP and DCPD as they affect plant germination, growth and productivity. Radioactivily tagged compounds will be used to determine the site of toxic effects and evaluate the potential for plant uptake and accumulation of sub-lethal concentrations.

C. Studies to Determine Relationship of DIMP Concentrations to Wheat Growth

Two studies have been conducted concerning the interaction of Wichita wheat and DIMP. One study was conducted at Ft. Detrick, Maryland and the other study was conducted at RMA. To date (1 May 1975) summaries of both studies are presented below.

1. Ft. Detrick Study

a. This study was started in September 1974 to determine the effect of 0.5, 2.5, 5.0 and 10.0 parts per million (ppm) aqueous solutions of DIMP on the development of wheat from germination of maturity. Ordinary tap water was used for the control wheat. During the study, data collected was limited to external, visual observation of the plants. This study was completed in February and no difference in plant maturation or mortality was observed between wheat watered with tap water and wheat watered with DIMP solutions.

b. A second study was initiated in December 1974 to determine the effect of 10.0 and 40.0 ppm aqueous solutions in both DIMP and DCPD. Again, tap water was used for the control wheat. This study will be completed in May 1975. Results to date are as follows:

(1) Wheat watered with DIMP solutions developed browning at the distal ends of their leaves (a natural occurrance) before the control wheat developed browning.

(2) No difference in plant mortality has been observed between wheat watered with tap water and wheat watered with DIMP solutions.

(3) No difference in plant maturation or mortality has been observed between wheat watered with tap water and wheat watered with DCPD solutions.

c. A third study was initiated in November '74 to determine the effect of various concentrations and mixtures of DIMP and DCPD on two species of black valentine beans. This study was completed in January '75. It appears that some leaf wilting and browning occurs with the lower concentrations and increases with higher concentrations; however, results of this study are considered inconclusive.

2. RMA Study

Two small fields of Wichita wheat were planted at RMA on 30 September 74 at a rate of sixty (60) pounds per acre. These fields were located in the section of land due north of Reservoir F. The southerly field was planted with 1973 seed and the northerly field was planted with 1974 seed. Weekly observations were started in February '74 for plant color, maturation and mortality. Results to date are as follows:

a. Plants germinated from 1973 seed appeared normal. Leaf browning occurred in April but had disappeared by 1 May.

b. In the northeast half of the field planted from 1974 seed, the plants appeared normal but slightly behind the maturation rate of 1973 seed wheat. Again, leaf browning occurred in April but had disappeared by 1 May. The southwest half of this field exhibited surface dampness and practically 100 percent mortality. The surface dampness is caused by low ground and high aquifer.

3. Future Studies

a. The studies at Ft. Detrick will be completed by 31 May 75.

b. The field study at RMA will be completed by 31 August 75. At harvest time (July), yield will be determined and the plants analyzed for DIMP. The milling and baking qualities of grain will be evaluated. Soil samples will be collected in June and July and analyzed for DIMP. Identical procedures will be conducted on control wheat selected from an off-post field.

VIII. MILESTONE CHART

A. All work currently planned is addressed in the Milestone Chart (Table 8-1). The review/decision dates provided for reassessing this plan are tentative and subject to adjustment at any time. The review dates were selected for the following reasons:

1. 1 Sep 75 -- a. Most actions completed to preclude further water contamination.

   b. Initial results of water sampling/analysis available.

   c. Phase I of computer model completed.

   d. Initial EA DIMP toxicity results available.

   e. RMA/Ft. Detrick vegetation study results available.

2. 1 Dec 75 -- a. Initial results of revised water sampling/analysis program available.

   b. Phase II of computer model completed.

   c. EA DIMP toxicity studies completed.

3. 1 Mar 76 -- a. Acute/sub-acute DIMP and DCPD toxicity studies completed by Surgeon General.

4. 1 Jun 76 -- a. Initial results of 2nd revised water sampling/analysis program available.

   b. Phase III of computer model completed.

5. 1 Aug 76 -- a. Surgeon General vegetation studies for DIMP and DCPD completed.

B. The off-post contamination program will undergo continual evaluation as new data is produced. The review dates are only offered as check points where various data should be integrated and analyzed to reassess the scope of the overall off-post contamination program.

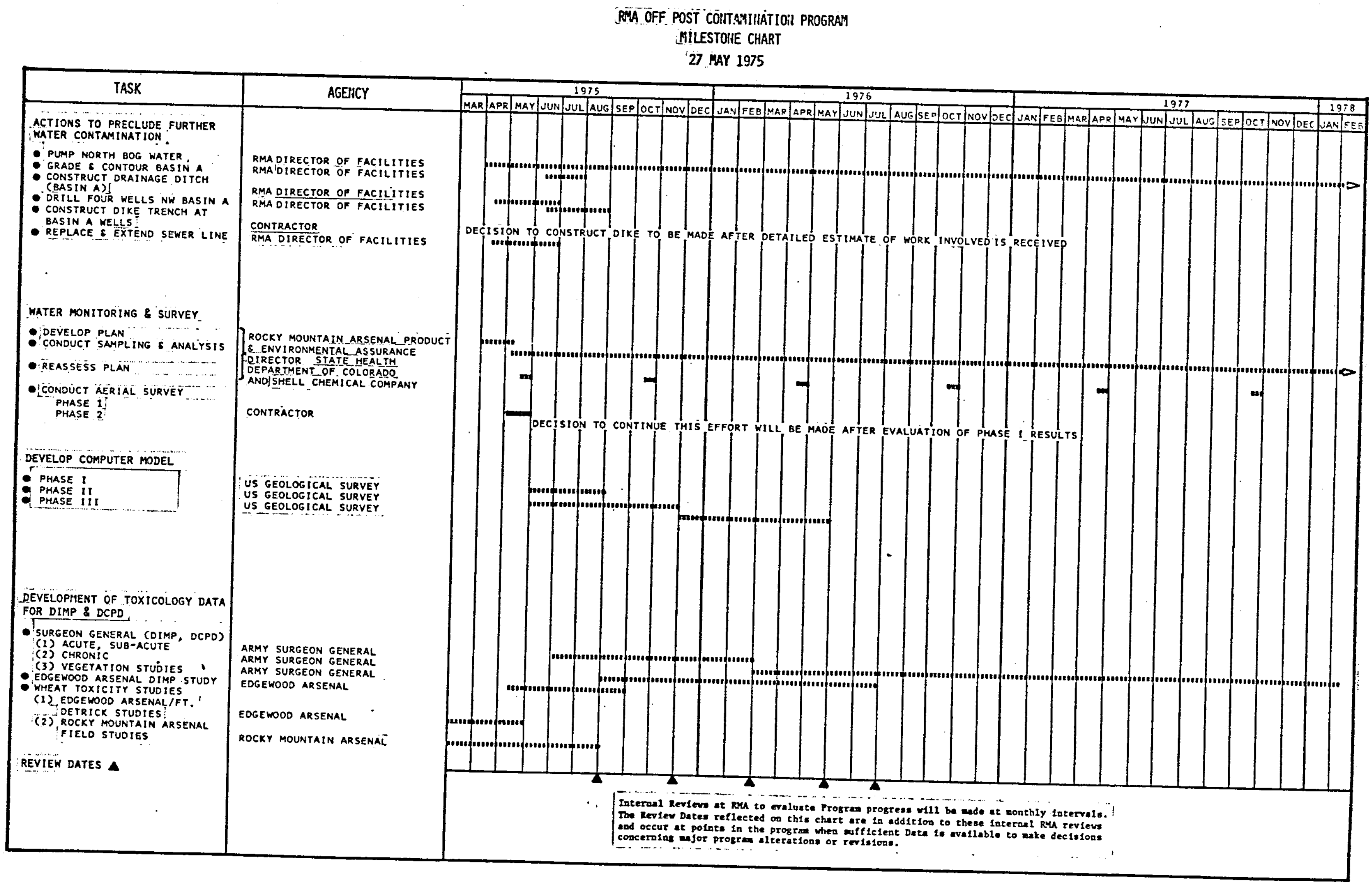


Table 8-1. RMA Milestone Schedule

IX. ESTIMATED COST

1. A detailed breakdown of the estimated costs for the off-post contamination program are presented in Table 9-1.

2. In addition to the FY 76 costs shown in the Table, FY 77, 78, 79 and 80 costs for water sampling and analysis have been estimated as follows:

FY	ESTIMATED COST	STATE SAMP/ANALYSIS COSTS
77	182,000	(93,600)
78	182,000	(83,200)
79	125,000	(72,800)
80	125,000	(52,000)

These estimated costs assume a 10 percent reduction in the number of wells (currently 50) to be sampled at each six month reassessment period until the level reaches ten wells. The ten-well sampling and analysis program is considered a minimum water monitoring requirement in future years. State sampling and analysis costs are shown in the event the Army must pay for this effort.

3. FY 77 costs for the Surgeon General's DIMP and DCPD toxicity studies are estimated at $1,000,000. Both FY 76 and FY 77 Surgeon General funds have been programmed in the PMO's RDT and E projected budget.

CONTROL

OFF-POST CONTAMINATION PROGRAM
ESTIMATED COSTS

ACTIONS TO PRECLUDE FURTHER WATER CONTAMINATION	FY 75 $	FY 76 $
PUMP NORTH BOG WATER TO BASIN F	5,000	12,000
GRADE & CONTOUR BASIN A	5,000	
DRILL FOUR WELLS (BASIN A)	20,000	8,000
CONSTRUCT DIKE TRENCH AT (BASIN A) WELLS		250,000
REPLACE & EXTEND SEWER LINE	5,000	
WATER MONITORING & SURVEY		
DEVELOP SAMPLING PLAN	18,000	
CONDUCT SAMPLING & ANALYSIS	16,500	320,000 (104,000)*
REASSESS PLAN		
CONDUCT AERIAL SURVEY	8,000	
DEVELOP COMPUTER MODEL	66,300	30,000 (Phase III)
DEVELOPMENT OF STANDARDS		
SURGEON GENERAL (DIMP-DCPD)		
ACUTE/CHRONIC STUDIES		400,000
EA DIMP STUDY	30,000	30,000
RMA WHEAT TOXICITY STUDIES	10,000	101,000
WHEAT TOXICITY STUDY (DIMP)	15,000	
	$198,800	$1,151,000 (104,000)

*NOTE: Needed if required to pay for State Sampling and Analysis of Off-Post Wells

Table 9-1. Estimated Costs

DESCRIPTION OF CONTAMINANTS

I. DIMP

A. DIMP is the commonly accepted abbreviation for the compound Diisopropylmethylphosphonate, and it is produced as a 2-3 percent impurity in the manufacture of the nerve gas, GS or SARIN (isopropylmethylphosphonofluoridate). There is no scientific evidence that DIMP is a metabolic or environmental product of GB.

B. DIMP is a colorless liquid with a b.p. 174°C at atmospheric pressure. A gas-liquid chromoatographic analysis method with a flame ionization detector has been used by both Edgewood Arsenal and Shell Chemical Company for the identification and determination of DIMP at levels of less than 1 ppm.

C. A comprehensive search of the published literature for toxicological data on DIMP was negative. Likewise, a search of Defense Documentation Center records was negative.

D. Unpublished data on the acute toxicity of DIMP is as follows:

intravenous rabbit, LD_{50}	100 but 200 mg/kg
dermal rabbit, LD_{50}	200 mg/kg
subcutaneous rat, LD_{50}	200 mg/kg
intraperitoneal mouse, LD_{50}	250 md/kg

eye irritation rabbit - 0.25 mg caused irritation and moderate degree of corneal damage which was reversible

inhalation mice - CT 25000 (no deaths after 14 days)

Consideration of this limited toxicity data indicates that DIMP is fairly toxic to experimental animals, and could be irritating or corrosive to the eyy.

E. Limited experiments, also unpublished, indicate that DIMP is a very weak inhibitor of cholinesterase activity.

F. A recent report by Bailin, et al. (Envir. Scl. Tech., 1975, 9, 254) stated that microwaves were able to decompose efficiently small quantities of DIMP in a mixture of phosphoric acid, dealkylated phosphonic acids and phosphorus pentoxide. Experiments are continuing with this method of detoxification (supported by AEHA, Edgewood Arsenal contract).

G. The Vegetation Control Division, Chem. Lab., Edgewood Arsenal, has conducted some experiments of the effect of DIMP on wheat. Ten ppm of DIMP does not effect wheat seedlings while 40 ppm is toxic. Field experiments conducted during 1955 showed that 1 ppm DIMP had no effect on numerous crop plants including beans, radishes, oats and rice.

H. The available toxicological data on DIMP is not adequate for an accurate evaluation of its toxic potential. The following experiments would appear to be necessary.

1. Determination of acute oral and dermal LD_{50} in rats and mice.

2. Ocular and dermal irritation studies using rabbits.

3. Ninety-day feeding study in rats.

4. Studies on the metabolism in experimental animals to include absorption, distribution, biotransformation, excretion and pharmacokinetics.

5. Determination of 96 hr. TL_m for fish species.

6. Phytotoxicity studies on crop and other growing plants.

7. Measurements of possible anticholinesterase activity of blood or serum of experimental animals and of man if possible.

I. The information obtained from the above experiments should indicate the nature of further long term studies that should be undertaken for a complete assessment of toxicity of DIMP to mammals, aquatic organisms and plants.

II. DCPD

A. DCPD is the commonly accepted abbreviation for the compound Dicyclopentadine (3a, 4, 7, 7a-tetrahydro-4, 7-methanoindene). DCPD is used extensively as an intermediate by the agricultural chemical industry in the manufacture of the organo-chlorine pesticides aldrin, dieldrin, endrin and chlordane.

B. DCPD is a clear colorless liquid with a b.p. 170°C but soluble in ethyl alcohol and ether. A gas-liquid chromatographic analysis method for DCPD using a flame ionization detector has been described.

C. A search of the published literature for mammalian toxicity of DCPD yielded the following data:

1. Acute toxicity:	oral rat, LD_{50}	353 (262-478), 410 (310-530) mg/Kg
	intraperitoneal rat, LD_{50}	200, 310 mg/kg
	intraperitoneal mouse LD_{50}	200 mg/kg
	dermal rabbit, LC_{50}	5080 (3110-8290), 4460 (2440-8150). 6720 (3150-14360) mg/kg

The pathological effects in rats were typical of irritating hydrocarbons when administered orally in large doses. The compound is slightly to moderately toxic by the dermal route and highly toxic by the oral route in single dose studies.

2. Inhalation: rat, LC_{50} (4 hr) 660 (553-817) 359, 383 ppm
male mouse LC_{50} (4 hr) 145 ppm
male rabbit LC_{50} (4 hr) 771 ppm
rat LT_{50} 1 hr (saturated vapor)
2500 ppm/1 hr rat, 1 of 4 rats dead
2000 "/4 hr rat, 4 of 6 rats dead
1000 "/4 hr rat, 4 of 4 rats dead
500 "/4 hr rat, 1 of 6 rats dead
250 "/10x6 hr rat, 1 of 4 rats dead
100 "/15x6 hr rat, 4 of 4 rats survived

3. Chronic toxicity and carcinogenicity: The carcinogenicity of DCPD by intramuscular injection in the rat is currently being investigated under an NCI contract at the Institute of Chemical Biology, San Francisco University (Dr. A. Furst).

D. To date, no TLV has been established, but Gerarde (See Patty, Vol II, p. 1217) suggested "a value of 100 ppm seems reasonable based on the limited toxicity data available and extrapolation from similar chemicals." Kinkead et al (Toxicol. Appl. Pharmocol., 1971, 20, 552) have suggested a "hygienic starndard" for man of 5 ppm. The TLV for DCPD recommended by Russian workers is 0.185 ppm (1 mg/m^3).

E. The Vegetation Control Division, Chem-Lab, Edgewood Arsenal, has carried out some preliminary experiments with DCPD on bean plants. The compound appears to have no effect on growth at both 10 and 40 ppm.

F. The available toxicological data on DCPD is not adequate for an evaluation of its toxic potential. The following experiments would appear to be necessary:

1. Determination of acute oral and dermal LD_{50} in rats and mice.

2. Ocular and dermal irritation studies using rabbits.

3. Ninety-day feeding study in rats.

4. Studies on the metabolism in experimental animals to include absorptions, distribution, biotransformation, excretion and pharmacokinetics.

5. Determination of 96 hr. TL_m for fish species.

6. Phytotoxicity studies on crop and other growing plants.

G. The information obtained from the above experiments should indicate the nature of further long-term studies that should be undertaken for a complete assessment of toxicity of DCPD to mammals, aquatic organisms, and plants.